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Physiology and Clinical Medicine: Bridging the Gap

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Many have been the reports, papers, and letters offered to the medical and academic world, countless the hours and great the discussion expended in endeavours to bridge the gap between the medical sciences and clinical medicine. To intrude upon problems which experienced medical designers have found extremely difficult, and particularly to do so at the height of a threat to the structure of civilization itself, must require a substantial excuse. In self-protection we tender a twofold plea for consideration. First, we do so at the behest of one who has always been in the forefront of educational reform in medicine; secondly, ours, as a new school, has not only the opportunity denied to older institutions, but also the duty of testing out ideas which seem desirable. The time, also, is not as inappropriate as it may at first sight appear. It has been laid down by defence authorities in both Great Britain and the Commonwealth that medical training must continue. It is incumbent upon the university authorities, therefore, to see that the training is carried out as expeditiously, thoroughly, and efficiently as possible. No training programme which is built up of unconnected parts or which permits personal antagonism to influence progress can pretend to any of these desiderata.

The Problem

The first essential to clear discussion is a clear statement of the problem. To us a paraphrase of paragraph 16 of the "Report of the Conference of Representatives" (1935) fills this requirement: "How can the course in physiology be designed to give the student of average ability such knowledge and such education, in so far as the subject is concerned, as will enable him to approach the problems of practice with some degree of confidence and with a legitimate hope that his scientific outlook on health and disease will enable him to learn from subsequent observation and experience?"

The outstanding features of the problem as thus defined are: (*a*) We are concerned with a student of average ability. (*b*) He is to receive both knowledge and education. (*c*) He is to approach his problems, not pick them up unintelligently and sort them as best he may into classically arranged compartments. Three special difficulties affect the solution of this problem. The first of these is the enormous growth in physiological knowledge of recent years. Professors of two generations ago were able to maintain a reasonable acquaintance with most of the branches of their subject; whereas to-day even the full-time research worker is hard put to it to keep abreast of the literature in his own small field. The second great difficulty arises from the first. It is that of maintaining contact between the various branches of physiological knowledge and inquiry. Such maintenance of contact is essential if a balanced educational dietary is to be provided for the student of average digestive abilities. This difficulty of maintaining balance is in some respects made greater by the third, that of the special demands of medical studentship. That there are special demands cannot be gainsaid, and indeed they find expression in the definition of the problem enunciated above. It is the weight of concession to be given to these three difficulties that has conduced to much of the verbal exchange and difficulty of fulfilment.

Proposed Solutions

Suggestions for meeting these difficulties put forward by the representatives of the Universities of Oxford, Cambridge, and London, the Colleges of Physicians and Surgeons, and the Society of Apothecaries included the following: (*a*) the stressing of the physiology of man; (*b*) the co-operation of the clinical staff; (*c*) the demon-

stration of deranged functions in clinical cases; (*d*) the basing of examinations on the student's grasp of function rather than memorization of detail.

The interim report of the Curriculum Committee of the General Medical Council suggested that too much attention was given in some schools to branches of physiology of little vocational value, and that physiology and clinical medicine should be brought into closer relation both by the continuation of instruction in applied physiology into the clinical years and by the association of clinicians with the teaching of physiology. These suggestions were incorporated in the resolutions adopted by the General Medical Council on May 29, 1936, and put into operation as from November, 1938.

The need for correlation of clinical problems with physiological teaching finds ample confirmation in the publication and widespread use of such textbooks as Wiggers's *Physiology in Health and Disease,* Samson Wright's *Applied Physiology,* and Best and Taylor's *Physiological Basis of Medical Practice,* which make a substantial contribution to the solution of the problem.

To the many addresses dealing with this subject we shall make no detailed reference. Each endeavours to recondition some essential part of the general structure of medical education, and all should be studied by medical administrators.

The Position in Queensland

The Faculty of Medicine in the University of Queensland was founded in 1936 by the establishment of Departments of Anatomy and Physiology. Departments of Pathology, Medicine, Surgery, Obstetrics, Social and Tropical Medicine, and Medical Psychology followed. The curriculum as a whole is described elsewhere (*Medical Journal of Australia*). It is sufficient here to point out three matters of considerable influence upon the design of the syllabus for physiology.

The most significant matter is the newness of the school. We do not know how long it is since a new medical school was established in the British Empire, but it is over fifty years since the last one was established in Australia. Not only is it newborn, but its birth was preceded by intense criticism of medical teaching from within as well as without. Of it, as of modern children in general, its parents are able to say, "You have opportunities unheard of in my day." With increased oppor-

tunities, however, go increased responsibilities. It is incumbent upon the school to give the best possible expression to the desires and to heed the admonitions of its elders.

On the other hand, this school was founded upon a definite understanding that due weight in teaching and due attention in research would be given to the problem of tropical settlement by white races. In the eyes of some, such directions will undoubtedly appear parochial and restrictive of scientific freedom. To others a definite objective such as that laid down will appear a very much better reason for the establishment of a faculty than the desire to create yet another factory for the mass production of medical practitioners. Whatever the individual opinion, however, the terms are clear and must be given due consideration in the design of any syllabus.

The third matter evolves to a certain extent from the second. The Physiology Department, while founded in the Faculty of Medicine, has to provide adequate teaching not only for medical students but also for students in the Faculties of Dentistry, Science, and Veterinary Science. Their needs are not merely adventitious: their services form an integral part of the wider problem of tropical settlement. But staff, funds, and time have material limits, so that as much of the instruction must be given on a conjoint basis as is consistent with efficiency.

The Solution adopted in Queensland

The complete course in physiology for medical students extends over two years, each of three terms. Biochemistry is given by a separate lecturer, but under the control of the professor of physiology, and is closely integrated with the physiological side of the course. The whole course is planned on a progressive basis, the student passing successively from the familiar to the unfamiliar, and developing his knowledge in integrative fashion.

The First Year

In the first year the instruction is biased towards the theoretical, basic data are acquired, and learning discipline is instilled. The practical work of this year does not begin until the second term, except in biochemistry, and remains behind the didactic teaching. There is a deliberate attempt here to save the younger student from himself by forcing the pace, to cover the greater part of

the memory work, and to reveal the weaker student before he is irrevocably committed to the course.

The first twenty lectures in physiology deal with the physiology of tissues. The student has done biology, chemistry (including some organic and physical chemistry), and physics. He knows the different kinds of tissues in an elementary fashion, and he is undergoing at the same time an intensive course in histology. It is explained to him that this section of the work deals with the fundamental physiological units, the building bricks, from which he will learn to build up the entire organism as a working machine. The syllabus includes:

> Properties of nervous tissue, muscle tissue, the nerve–muscle unit, endothelium, reticulo-endothelium, haematopoietic tissue, connective and skeletal tissues, and the cell membrane, and the physiological aspects of differentiation and growth.

The second twenty lectures in physiology deal with the physiology of organs. The fundamental units with which the student is now familiar are studied, combined in the different patterns which make up organs, much as building bricks of different kinds go to make up walls, floors, and ceilings. There is of necessity some repetition of what has gone before and some anticipation of what is to come, but this is part of the synthetic process which runs throughout the teaching. This portion of the syllabus includes:

> The general physiology of organs of general sensation, special sensation, conation, absorption, transference, storage, secretion, excretion, integration, defence, and reproduction.

While this instruction in physiology has been progressing lectures in fundamental biochemistry have been developing from the point at which the organic and physical chemistry of the previous year ceased. The syllabus here includes:

> Elements occurring in the body, the chemistry of carbohydrates and lipoids, hydrogen-ion concentration, buffers, the properties of colloids, the chemistry of proteins and salts, the action of enzymes, and the properties of vitamins.

In addition, a course of ten lectures in the principles of scientific method is given by arrangement with the Department of Philosophy.

During this period the student has been led progressively to conduct from fields previously familiar a brief but comprehensive survey of fundamental physiology. He is

now acquainted with living matter, not as a static structural entity, but as an ever-changing, adaptable, purposive being. Nothing in his subsequent learning should surprise him; rather should it appeal to him as the logical development of what he has already witnessed, moulded by opportunity and selection to the service of evolution. To him the intricacies of the circulatory system should not be something that is, but something that had to be; something that has evolved as offering most to the varying demands of the entire organism.

The student is now fit to take up the study of systematic physiology. Moreover, he is in a position to cover the ground rapidly. In sharp contradistinction to the previous sections, his textbooks are quite adequate, so that lectures cease to be didactic, becoming instead guides and tutorials. In the second half of his first year he is led relentlessly through the systems—the classical physiology. This demands much labour from the student; but the demand is deliberate, and follows the initial period of training. The weaker members who did not or could not profit by that training now reveal themselves, and by examination may be saved unnecessary pain and expense of continuance. Biochemical instruction during this period co-operates by covering the ground of chemical metabolism—carbohydrates, fat, protein, nucleo-protein, and mineral.

Practical work in biochemistry continues at an even pace throughout the year in parallel with the lectures. There is no practical work in physiology in the first term. In the second term it deals with the behaviour of tissues and organs, while in the third term the behaviour of certain systems is studied. The syllabus is as follows:

Second term: properties of nerve and muscle as shown by the nerve–muscle preparation; haematology, normal and reactive; properties of cell membranes; dissection of the eye; examination of special tissue functions; examination of general sensation.

Third term: cardiac action; haemodynamics; haemic respiratory function; pulmonary respiration.

The Second Year

The second year, in contradistinction to the first, is predominantly practical in character. The knowledge already gained is correlated and applied to the future problems of medicine, and the student is given increasing opportunities of unravelling problems for himself in his

individual style. The aim is to finish the year with students who are thoroughly familiar with the human body as a working machine, who possess a common-sense appreciation of what might go wrong, who are fit and keen to learn the art of medicine as well as study the detailed manifestations of disease.

In the first term twenty lectures on integration and adaptation teach the students first to study the manner in which the various systems are integrated into a single reactant organism, and then to examine the way in which this intact organism adapts itself to changes in the environment. The syllabus reads as follows:

> Integration: nervous co-ordination at different levels; the tonic and balanced states; chemical integration; interaction of endocrines; interrelation of nervous and chemical mechanisms.
>
> Adaptation: adaptation of whole organism to exercise, heat, altitude, haemorrhage, acid-base disturbances, infection.

This is followed in the second term by a further series of twenty lectures on clinical applications. This course marks the culmination of the didactic teaching of the physiological section. The plan of the lecture is of some importance. The typical lecture is divided into three parts. In the first the mechanism of some important bodily function is outlined; in the second, consideration is given upon an *a priori* basis to the ways in which this mechanism might become disturbed; while the third is devoted to a brief survey of the more important clinical events in which such disturbances occur. The lecture course for the current year includes the following:

> Disorders of sensation, vision, effector mechanism, cardiac rhythm and rate, cardiac mechanism, haematopoiesis, peripheral vessels, respiration, gastric function, intestinal function, carbohydrate metabolism, fat and protein metabolism, endocrine balance, energy metabolism, renal function, tissue hydration.

While these are proceeding the lecture course in biochemistry is dealing with blood, urine, milk, special organs, tissue respiration, and the embryo. The clinical applications of biochemistry are not covered until the third term. These last lectures are more pragmatic in design, dealing directly with the use of gastric test meals, urine analysis, renal function tests, glucose-tolerance tests, examination of the cerebrospinal fluid, and kindred methods of biochemical investigation.

The practical work of the year is carried out entirely on the group system. In the physiological section it starts with "round games," the class being divided into groups of four, each group conducting a different experiment and moving on to the next experiment on the succeeding day. In this way the study of the systems begun the preceding year is completed, while at the same time individual talent and initiative can be drawn out. This objective is carried a stage further in the second term, when teams investigate the integrative and adaptative reactions of their own bodies. One member becomes the subject, while each of the others has a specific duty. Thus in exercise experiments, for example, one records the pulse rate, one the blood pressure, one the respiratory volume and rate, and two measure the metabolic rate, while others analyse the venous blood for gaseous and other changes. The subject afterwards correlates the findings.

In the second term, also, the practical demonstration of the clinical applications begins. Once a week the class meets in the hospital lecture theatre. A selected patient is brought in. The professor of physiology gives the class such information as he thinks necessary, and then proceeds by individual questioning and examination of the patient to draw the class on to a consideration of the physiological mechanisms and their disorders which might explain the facts before it. In this work it is essential to keep certain principles clearly in mind. In the first place, it is the physiological mechanism and not the disease which is being demonstrated. Secondly, it is the class which must make the decisions in so far as its knowledge, the unaided senses, and common sense can lead it. It is fatally easy for the demonstrator to accept the initiative from the class and to branch off into discussions of purely clinical matters instead of illustrating the importance of physiological knowledge and physiological modes of thought in the approach to clinical problems. The following conditions were demonstrated last year:

> Dyspnoea of haemic origin, dyspnoea of respiratory origin, referred cardiac pain, upper motor neurone paralysis, lower motor neurone paralysis, weakness of diabetic origin, obstructive oedema, cardiac oedema, renal oedema, Parkinsonism, hyperpiesis, vasospastic headache, obstructive jaundice, hyperaesthesia, cyanosis, Addison's disease, diabetic ischaemia, diabetic coma, hypoglycaemia.

In the third term this practical study of clinical applications is intensified. The class is divided into groups of four. The weekly session begins with the professor

dictating notes to each group on the main features of the patient allotted to it. The group is given half an hour in which to question the patient and make any reasonable examination with a view to detecting any disturbances of his physiology which may be present. At the end of that time the group is given the case-history sheets and told to rectify omissions and discuss the mechanism at work. After a further half-hour's study the professor conducts a cross-examination of the group members on their observations, deductions, and knowledge. The principles enunciated for the preceding class-teaching must again be kept clearly in mind. It is the mechanism, not the disease, which is important, and the student must follow it for himself. To cross-examine twelve groups of students, each on a different patient, is not an easy morning's work, but his cross-examination is the most valuable part of the session. It must, moreover, be undertaken by someone in authority, whose good opinion it might be advisable to secure—at least for the remaining few weeks of the year. Indeed, the students find it good revision and also good practice for the forthcoming viva voce examinations.

Practical biochemistry continues its even tenor during the second year, following similar lines of development as regards individuality and clinical application. In the first term analysis of blood and urine is systematically and thoroughly covered. In the second term individual projects are allotted to groups, to encourage resourcefulness and to inculcate some idea of biochemical investigation. Among the projects issued in 1939 were:

> Preparation of crystalline pepsin, extraction of hepatoflavine, preparation of haemoglobin and its crystalline derivatives, preparation of hypoxanthine and its oxidase, determination of hexose monophosphate in muscle, investigation of ascorbic acid in vegetables, preparation and assay of adrenaline, preparation and assay of secretin.

At the end of the term one member of each group presents its experience—not always successful—to the class in the form of a seminar.

In the third term practical biochemical investigations of bodily function are conducted by the whole class on each other or on material obtained from hospital. While in general these run parallel with the lectures, the availability of material at times determines the order.

It is the general practice in Australian universities to hold examinations at the end of each academic year.

Permission to proceed to the studies of the next year is conditional upon passing these examinations. Under certain conditions Supplementary Examinations are granted towards the end of the long vacation. This system is followed in Queensland. It has the advantages of strengthening discipline and of weeding out the weak students at an earlier stage. The degree examinations are not exclusive, as questions may quite well be set in the third degree examination bearing on second-year work, while in the Final Examination anything relevant to clinical knowledge may be introduced. In the first examination in physiology evidence of learning and a certain amount of detail are required ; in the second examination in physiology understanding rather than mere feats of memory is sought.

Clinical Years

We have been at pains to describe the way in which links have been extended from physiology forward to clinical medicine and surgery. The interrelationship has also been strengthened by the reverse process of reference to physiology in the course of clinical instruction. The teaching staff of the later years is continually active in encouraging students to build their art and detailed knowledge of medical practice on the firm foundation of anatomical and physiological understanding. Interdepartmental consultation is of frequent occurrence on controversial matters, and many clinical teachers have taken the opportunity of postgraduate classes to reinforce their physiological knowledge. Doubtless the converse process will soon be possible.

A feature to be taken up this year is the weekly holding of a combined clinical discussion in which all departments will share. While this is primarily designed for the benefit of final-year students the results will have a wider effect upon the co-ordination of teaching.

Difficulties to be Overcome

The volume of discussion that has surrounded this subject affords some indication of the difficulty of its solution. To a certain extent we were, in Queensland, freed from difficulties attendant upon local tradition, but others remained. It may be instructive to conclude with remarks thereon.

The first difficulty was that of obtaining sufficient qualified assistance. There were no local medical graduates, while those from southern universities found

employment near their alma mater or came northwards for clinical experience. There were no science graduates with a training in physiology. The staff had to shoulder the whole responsibility for teaching, even to teaching laboratory attendants the rudiments of their craft. Luckily, this was essentially a problem of time. We were fortunate in our technical staff, who quickly absorbed the new knowledge and are now invaluable; we have three years of science graduates trained at least in biochemistry (three students with honours); while before long we shall have our own graduates as resident medical officers in the hospital. The appointment of a medical man (F. J. Booth) as the first lecturer in physiology afforded great assistance to the clinical side.

The second difficulty was that of introducing the idea of bedside physiology to a medical world not in immediate contact with recent educational developments. Fortunately, we quickly gained some influential adherents from the ranks of the profession who maintained our courage until the others had an opportunity of studying the scheme in operation and of becoming converted to the faith. It soon became evident that the physiology of to-day had very much more to offer the practitioner of medicine than might have been expected from older teaching.

A third difficulty, universally to be found, is the volume of routine administrative work encountered. This appears to be inseparable from the conduct of an active and growing department. Organization and discrimination can afford some protection, but responsibility demands a certain degree of personal attention. The employment of special administrators mainly changes old problems for new and at increased cost. These duties remain the chief handicap to teaching and research efficiency.

The problem of the balance between teaching and research has engaged us, as it has everyone else. Our policy has been clear: teaching is the first duty of the school, and its demands must preferentially receive reasonable satisfaction; but every teacher must be granted opportunity to carry out investigational work, and future research workers must be encouraged and trained in general principles. This of course restricts the rate of teaching development, but only in details. It is, moreover, deliberately done in holding a balance between these functions.

The special requirements of tropical settlement are met by the introduction of lectures on the heat-regulating mechanism and adaptation to diminished heat loss, and

also by the conduct of practical classes on kindred matters in which the student makes himself familiar with methods of atmospheric and climatic assessment and the reactions of his own body to hot climates provided in the department's air-conditioning room. The main difficulty in this section is the preservation of a just balance with the remainder of the course, as this subject happens to be the main research interest of the professor.

The needs of non-medical students have been met in most cases by introduction of the " tree " system. During the first three terms students of the Faculties of Science and Veterinary Science attend the same classes as the medical students. During the fourth term veterinary science students branch off on to special courses for most of their work, science students for some of it. In the fifth term the dissociation from medicine becomes complete, but some association between science and veterinary science is maintained to the end. In the case of dentistry and physiotherapy it has been found necessary to provide conjoint classes separate from those of the other students.

Conclusion

In these pages we have outlined an attempt made by a newly established department in the youngest Dominion to give practical expression to ideals which have for some time appealed to the teachers of the motherland. The opportunity has been taken not only of establishing the closest links between the teaching of physiology and the problems of medical practice, but also of establishing from the very beginning of the subject a policy of progressive and co-ordinated transition. The incoming student, armed with a knowledge of fundamental physical, chemical, and biological conceptions, is first led to apply these to cellular behaviour. He then proceeds to study groups of cells working together as organs, organs co-ordinated as systems, systems integrated into an intact organism. Finally, he discovers how this integrated being reacts to the vicissitudes of normal and abnormal environments. The teachers have now done their best: it remains with the student to succeed where Pygmalion failed.